Interdisciplinary Project-Based Learning: An experience with Digital Games and Music Production students

Claudio Carvilhe*‡, Glaucio H. M. Moro*‡, Anderson Vermonde‡, Jose G. Noronha Filho*†‡, Carlos N. Silla Jr.*†§
*Computer Music Technology Laboratory (Onloop), Pontifícia Universidade Católica do Paraná (PUCPR), Brazil
†Graduate Program in Computer Science (PPGIA), Pontifícia Universidade Católica do Paraná (PUCPR), Brazil
‡Digtal Games Development Course, Pontifícia Universidade Católica do Paraná (PUCPR), Brazil
§ School of Information Technology, Halmstad University, Sweden

***Abstract*—This innovative practice full paper presents an interdisciplinary Project-Based Learning (IPBL) approach that relies on a challenge as a key part of the learning process. A project is proposed to the students from the perspective of creating a direct association between learning and doing. In this paper, we present a variation of PBL adding the interdisciplinary factor: we united students from different areas (digital games and music production) under the common objective of producing a complete sounded digital game. An additional difficulty was overcome since all classes took place remotely due to the Covid-19 pandemic. To accomplish this challenge, a remote structure of classes was created to facilitate interaction between students as much as possible. During one semester, 2 groups of undergraduates from these two areas studied different modules organized in parallel under the general objective of an integrative project. The integrated project spanned 17 weeks, with classes structured to accommodate the evolving needs of project development. Initially, the first three weeks operated independently, allowing for focused exploration within each module. Subsequently, collaborative efforts were emphasized during weeks 4, 6, 9, 10, 12, and 15, fostering synergy and collective progress across both domains. Game students were given the mission of producing a game from scratch. To music production students the mission was making a full package of sound and music to each respective game. Facing a common schedule, all students had periodic meetings to align production and deadlines. In the end 10 games were produced and sounded. Initial hypotheses were raised about what we expected because of this experience. To assist in the analysis of the results, all the students involved responded to surveys about what they experienced. The successes and the need for improvements observed are detailed in this paper based on the application of the proposed methodology during the period in question.**

***Index Terms*—Game Development, Game Audio, Game Music, Project-Based Learning, Digital Games.**

I. Introduction

Most problems in the world are solved by interdisciplinary teams, with people with different academic and technical backgrounds [1]. Despite its importance in the real world, developing meaningful interdisciplinary projects in academia remains a challenge. One way to address this challenge is to design engaging interdisciplinary project-based learning experiences aimed at students from different courses with the goal of developing a product that requires the complementary expertise of students from different courses. This approach is potentially beneficial for students from different courses, since they will have to interact and collaborate with their colleagues from a different course to successfully complete their interdisciplinary collaborative project.

In the context of the game industry, most game development teams often are interdisciplinary teams [2]. Considering that in our university, we have two undergraduate (music production and game development) courses that can be coordinated to develop an interdisciplinary integrated PBL experience that employs the complementary skills from the students of the different projects. From the perspective of music productions students, such a project might be their first productions for a complete project; this approach might also showcase them a different work area which they might have not thought about before; From the perspective of game development, this might be their first experience in working with a external team. This experience might also enhance their game development skills by learning and improving their communication with external teams. These students were brought together under a common objective: to develop an original digital game (involving the expertise of digital game students) with original SFX and music fully produced by Music Production students.

The main contribution of this paper is to present our experience with the active learning pedagogical methodology of project-based learning (PBL) [1; 3] adding an interdisciplinary thinking research applied with students from game development and music production courses. It should be noted that the experiments reported in this paper were conducted remotely due to the COVID 19 pandemic. However, it can be easily adapted to in person classes, or hybrid approaches.

II. Pedagogical Strategies

The integrated project discussed in this article deals with the modules of Creative Experience: Development of 3D Games, from the 4th semester of the Digital Games undergraduate course and the Game Audio discipline, from the 4th semester of the Music Production undergraduate course. These modules

were organised to take place weekly on the same days and times, which allows the teams to work together synchronously in some of these meetings. In the Digital Games undergraduate course, the course aims at the student to demonstrate his competence in creating simple games, contributing individually to the development of a project vertical Slice, which is usually done in teams. For game projects, it is not necessary for students to create all project elements from scratch, but rather to be able to integrate these elements into a coherent game experience. In the Music Production undergraduate course, the discipline foresees that the students mobilize the knowledge acquired previously in the course in a sound project, also usually done in teams.

In the area of game development, it is common to outsource specific parts of the project, such as sound tracks or certain visual elements, which are integrated into the project by the development team. Thus, the realization of this integrated project, in addition to meeting the specific needs of each module, also provided a dynamic very similar to what students will find in the job market. During the first weeks, the game development teams made the initial definitions and first prototypes of the projects, preparing a presentation with the project pitches. From the presentations, which were made in a joint class, the music production course class was organized into teams, each linked to a game project. During the semester, each class worked on its study topics individually, in line with the competences of each module, however there were also some joint alignment classes, where the teams met synchronously to work on projects and align the development of soundtracks and sound effects and their integration into game projects.

The classes took place in the remote format, both modules used Discord as a support platform for the classes, so during the classes together, the music class moved to the Discord game room, where the instructions for the activities were passed on to all the teams. In addition, each game team had its own text and audio rooms that were used in classes for meeting, recording and individual monitoring by the teachers. In this way, teams could also meet and exchange information outside of the synchronous moments in class.

For the final delivery of the projects, special care was needed when evaluating the projects, since even though the projects for both games and music production were delivered together, each discipline evaluated the participation of its students according to their own learning outcomes. It was also necessary to define rules for independent evaluation of the project delivery, in case a music team did not finalize and deliver the audios, or if the games team was unable to finish the project or integrate the sounds. The following subsections present our pedagogical foundations, study topics, learning outcomes and schedule for both classes.

A. PBL and Education Interdisciplinarity between Sound Design, Arts and Programming Languages for Digital Games

This teaching experience involved students from different courses and schools. The Digital Games class, coming from

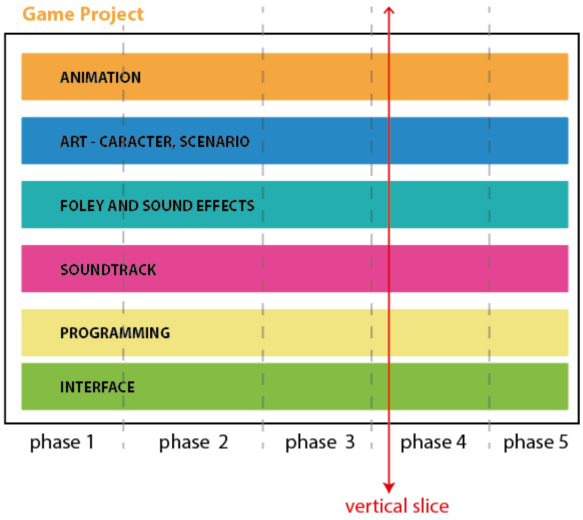

Fig. 1: Vertical slice.

the Technological Course in Digital Games at the Polytechnic School, took the *Creative Experience* module focused on Developing 3D Games. This range of integrations and professors require multiple specialties from lecturers, as they involve both professors specialized in programming and sound and music as arts and audiovisual technicians/theorists. A digital game soundtrack, in this specific case, does not depend only on itself, it is linked to a programmable interactive visual graphic interface and responds to these graphic and visual stimuli. We think of the digital game as a great product that unites interdisciplinary and needs multiple knowledge to be produced. The sound production class, from the Music Production Course at the School of Fine Arts, took the *Game Audio* module. In a similar way and also for having a certifying characteristic, the discipline corresponding to the second group also needed to aim at the final product - a sound game. In this way, an integrated project between classes and schools was established, implying that the students of the music production course were responsible for the sound production of the game developed by the game students.

Within this integrated process, and shaping the experience so that it was possible to create certifications for the disciplines that are integrated, the subject in question had a certifying nature, which implies the need to produce a vertical slice game (VS) project to obtain approval. The term vertical slice is widely used in the gaming industry and translates into creating a “cross slice” of a product, in our case a game, that is complete: It has sound, interface, graphics, animation and gameplay. This slice can just be a game screen. This technique aims to cover all stages of a game without the need for its complete production. We use this technique so that students can work in several stages within the class period, which in our case is biannual.

Figure 1 demonstrates an example of what a vertical slice would be for games. Let’s imagine that a group in question created a game script with five distinct phases. Instead of

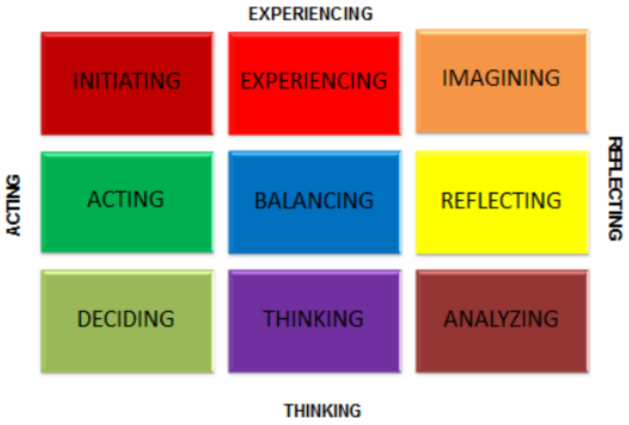

Fig. 2: The Kolb's Learning Style chart (Adapted from [4]).

producing scenarios, soundtrack, interfaces, animations and programming for all phases of the project, which would be unfeasible in a semester of classes, the group chose to produce a screen belonging to phase 4 of the game. This choice may have come from the group because they thought this phase would be more viable to produce. Even so, the group will need to produce the characters, the scenario, the soundtrack and the effects of the chosen stage. This gives the final artifact of delivery a much higher quality to the game.

These processes are part of an active methodology proposal called Project Based Learning, as an application methodology. The choice of methodology was due to the way in which the class project was constituted, with interdisciplinarity and processes within a project and it seemed to fit the class proposal perfectly. Learning by experiences, reflection, action and reaction are also in other Kolb works as the learning style as in the 9 stages of learning which they call The Kolb's Learning Style (Figure 2).

In it, experience and thinking are close, but on different sides, as well as acting and reflecting. Surrounded by these elements are the categories that, within a learning process, are sometimes pending more for one of the points. The points within are: Initiate, experience, imagine, act, balance, reflect, decide, think and analyze [4].

Thus, the processes that involve learning are connected with the student's action in the world, they do not just stay in a detached layer of theory and do not just go into a practice of serial reproduction without context or critical objective.

The activity itself is produced through a device that connects all actions. It's the project itself. For this, we use the thought of active learning pedagogical methodology of PBL.

Project Based Learning or just PBL is an active methodology based on project learning that consists of thinking about relationships focused on the skills and needs that the student can develop and take to their professional life, providing multifaceted learning experiences [1].

This type of theory brought to the classroom is extremely important in creating a cultural context close to that of professional life and in the construction of knowledge related to the identification and resolution of problems that the student will have to face [5].

Thus, we can imagine that the active methodology in PBL is a large process in which learning is carried out in the classroom, creating not only an environment disconnected from the work experience, but a micro experience of what would be a team project in a creative studio with professionals with different specialties, opinions and varied work processes.

It is possible to find Project Based Learning in several areas of knowledge. Musa et al. [6], comments that the method is a great way to think about skills and training in the modern field of work, as it involves processes of creativity and innovation for a proposed objective.

The University as a place of preparation for the job market must seek to create a vision that is not only technical for the student, it must provide critical confrontation and autonomy, and PBL can provide this type of meeting. Lou et al. [7], mentions PBL for the direct participation of students and how the group needs to negotiate solutions between several variables on the same problem, and that this type of methodology opens up possibilities of being combined with other forms of teaching through the concept of blended learning that mixes digital platforms and online interaction with other forms of direct interaction between students.

According to the definition of [8], blended learning is a formal education program that proposes to the student training moments using online resources and training moments where the student will be in the classroom with other students and the teacher.

It should be noted that these classes took place during the COVID-19 pandemic and therefore all interactions were online. We built on our previously reported experience in using discord as a emergency remote teaching platform during the COVID-19 pandemic [9] together with the active learning pedagogical methodology of PBL. By mixing digital platforms and online communication techniques for its application, we had a totally different application of the active learning pedagogical methodology and work-based projects. It would be like an interdisciplinary process of projects based on learning in the digital environment, as it uses a methodology applied exclusively online and digital, which had multiple professors from different fields within interdisciplinary relationships of knowledge. The IPBL aims at the same process of criticism, reflection and experience as the [4], bringing blended learning as a form of digital application.

PBL can be interpreted as interdisciplinary, from the point where they develop an understanding of concepts and skills in other disciplines, create a context that cuts across the elements in the classroom, and a real world. Students develop life skills as they apply interdisciplinary and disciplinary skills in a real-life context. Two lead to trans integration: project-based disciplinary learning and negotiating the curriculum routes [10].

TABLE I: STUDY TOPICS FOR DIGITAL GAMES STUDENTS

Study Topic	Main Goals
Game concept	Students develop conceptualization, prototyping and definitions of game aspects based on a selected theme.
Project Development	Students learn the interactive project development cycle, focused on playtest and refinement.
Project Management	Students are introduced to project and team management concepts, including interaction with external teams.
Post Production	Students learn the concepts of game polishing, completion and registering focused on vertical slice (or demo) of a product with great quality including sound production.
Asset Packing Creation	Students learn how to produce packages of art and programming.

TABLE II: STUDY TOPICS FOR MUSIC PRODUCTION STUDENTS

Study Topic	Main Goals
Sound Design Fundamentals.	Introduce the student to fundamentals relating to sound design for games.
Sound Production for games.	Students learn the audio producing, processing and sound synthesis focused on games. Introduce the student to the sound designer's workflow for games and their responsibilities in their day-to-day work.
Music Production for games.	Students learn music production principles focused on the game area.
Introduction to Audio programming.	Students have a first contact with game engines under the objective of understanding the audio requirements necessary for its implementation.

B. Study Topics and learning outcomes

The Creative Experience and Game Audio modules were initially built to be taught independently, covering the study topics detailed in Table I and Table II respectively. One of our hypotheses is that the disciplines can be taught together, from the point of common convergence: an integrated project. It is important to emphasize that both disciplines have a certifying characteristic, which implies the need to produce final deliveries that can be quantified.

Officially, in our context, the student of digital games must produce (as a learning outcome): *A digital game with context coherence, applying the appropriate technological tools, ensuring the proper functioning of the product, revealing critical sense and autonomy.*

Similarly, the student of music production must produce (as a learning outcome): *A sound production reflected in a library of SFX and music, meeting the criteria established in relation to the planning and production of sound artifacts necessary to compose a game project.*

At the end of the modules, as a learning outcome game students must have developed a game. Similarly, as a learning outcome music production students must have developed the complete sound production (SFX and music) of the game developed by the game students.

C. Modules Common Schedule

The integrated project took place over 17 weeks. Table III details the consolidated schedule of the two classes. Notice that Study topics related to the two classes and detailed in Table I and Table II are incorporated in III.

For each week, classes could follow independent or common schedules based on project development needs. In the first 3 weeks the classes were conducted independently. In weeks 4, 6, 9, 10, 12 and 15 classes were working together. The following subsections detail the interactions between the classes.

1) Week 4 - classes meet: Game projects were presented. On the occasion, digital games and music Production students were gathered in the same Discord room where all of they could watch the presentations.

2) Week 6 - music teams are allocated to projects: After a separate explanation (each teacher with their respective class) the classes were brought together to interact. Since the first checkpoint, where 16 (sixteen) project proposals were presented, many of these projects were not continued, as teams and new projects were rethought. Additionally, some of the original digital games teams chose to take full responsibility for producing sounds and music for their projects. Officially, 10 (ten) projects were elected to participate in the integrated project. These projects were presented to the music production students and a discussion was held among all about the best way to divide the project teams. It was unanimous among the students that the best and fairest way would be a lottery. For each team, a Tutor (more experienced student) was defined to serve as a "point of reference" to assist with some difficulties and doubts. Once the teams and tutors were defined, the students were brought together to start working together.All students from both classes were encouraged to interact outside the classroom in order to accelerate the development based on a list of initial audio needs.

3) Week 9 - Joint class between classes working remotely: The classes were gathered in a common remote classroom. Initially, all students from both classes were grouped into a single channel to hear the teachers' initial instructions before their interaction. The next moment was entirely dedicated to the interaction between students.

4) Week 10 - First playtest: The tenth week culminated with a first playtest of the developed games, consisting of an intermediate version intended for testing and feedback in an official event.

Digital games students worked for two weeks on the objective of generating a version of the game contemplating the sounds and music developed by music production students. In addition, each developer produced a teaser of the game, contemplating original music and preferably including some sound effects and gameplay.

5) Week 12 - Classes working together: In the twelfth week the classes were brought together in order to work together. The teams worked under the objective of closing the *audio asset list* of the projects.

TABLE III: DIGITAL GAMES AND MUSIC PRODUCTION STUDENTS COMMON SCHEDULE

Week	Digital Game students schedule	Music Production Students schedule
1	Presentation of the module, objectives and integrated project.	Presentation of the module, objectives and integrated project.
2	Game concept: Students do brainstorms of game proposals with pitches at the end.	Student´s play a simple game as a vehicle to study the Sound Design Fundamentals.
3	Game concept: Students start developing initial prototypes including presentation slides.	Sound production for games: student´s produce their first SFX based on an independent template project.
4	**First checkpoint - classes meet.**	**First checkpoint - classes meet.**
5	Project development: Week dedicated to the development of the initial prototype (game)	Sound Production for games: sound synthesis focused on games.
6	**Second checkpoint - music production teams are allocated to projects. Project management: Teams interact to produce a first list of sound needs for the project.**	**Second checkpoint - music production teams are allocated to projects. Project management: Teams interact to produce a first list of sound needs for the project.**
7	Project development.	Sound Production for games: sound designer's workflow for games.
8	Project management.	Music Production for games.
9	**Joint class between classes working remotely.**	**Joint class between classes working remotely.**
10	**First playtest event.**	**First playtest event.**
11	Week dedicated to the development of the integrated project (game).	Music Production for games. Week dedicated to the development of the integrated project (sound)
12	**Classes working together. Post production.**	**Teams interact to produce the final list of sound and music for the project.**
13	Post production. Asset packing creation. Reorganization of the teams.	Introduction to Audio programming.Reorganization of the teams.
14	Week dedicated to the development of the integrated project (game)	Week dedicated to the development of the integrated project (sound and music)
15	**Last official meeting.**	**Last official meeting.**
16	Finalization of the integrated project (game)	Finalization of the integrated project (sound and music)
17	Presentation and open play of projects.	Presentation and open play of projects.

During the meetings, teachers and tutors visited each team channel in order to make themselves available to answer possible questions from students. In addition, the teachers instructed the students to have discretion in the amount of sound items (SFX and music) in order to balance the amount of work between projects, minimizing the possibility of having a very large disparity in the amount of assets to be produced. The audio asset list template used by the students is available at: https://bit.ly/2024-FIE-IPBL.

6) Week 13 - Reorganization of the teams: Ten (10) game project proposals were selected to participate in this activity. Naturally, potential mishaps were expected with regard to projects being interrupted or teams dropping out or student reorganization between teams causing projects to disappear. Out the 10 selected projects, during week 13 one of them was interrupted due to withdrawal. The teachers then talked to each other and found a new project for one of the music production teams to develop their work. Thus, after the reorganization, 10 (ten) projects remained for the remaining of the course.

7) Week 15 - Last official meeting: After this last official meeting, music production students have the mission, in the space of this last week, of producing what is lacking in terms of sound effects and music, according to the previously defined audio asset list. At the same time, digital games students will have two weeks to finalize their projects. According to this schedule, music production students will finalize their production so that game students have a week to complete the final implementation of the audio assets.

8) Week 17 - Presentation and open play of projects: Table IV presents the 10 games produced and the place where it is possible to access them. Additionally, for each project it is possible to observe the the sound effects (SFX) and music produced. It is important to note the disparity in the amount of SFX produced for the games indicated by the numbers 5 and 9 in relation to the others. This was for two reasons: (i) there was no official limitation on the quantity of items to be produced; (ii) the number of items grew a lot just with simple variations of the same item.

TABLE IV: SUMMARY OF PRODUCTION

Game name	#sfx	#music	Available?[1]
1) Little Agnes' Grove	15	3	Freely Available
2) Monster Mansion	49	4	Freely Available
3) Larfleez	14	4	Not Publicly Available
4) Protomice	30	4	Freely Available
5) Paper Theater	165	4	Freely Available
6) Roube o Patife	33	6	Freely Available
7) Remains of a Sunday	14	2	Freely Available
8) Downhill Overdrive	43	4	Freely Available
9) Revolver Mix	79	3	Freely Available
10) Rinha de Carro	41	3	Freely Available

[1] The links for all available games are at: https://bit.ly/2024-FIE-IPBL

III. METHODOLOGY

We conducted research aimed at students based on feedback forms that were organized as follows:

- A specific form for Music Production students;
- A specific form for Digital Games students;

Notice that questionnaires were applied often using a 5 level Likert Scale [11]. The questionnaires were answered by all the students of the two classes. The Music Production class was made up of 28 students, 19 men and 9 women. The Digital Games class was made up of 29 students, 21 men and 8 women.

The questionnaires were built with the objective of providing us with information about 8 main hypotheses:

H#1: This was the first game sound production developed by music students.

H#2: The students had not previously developed a sound and music project for any area.

H#3: An integrated project proposed based on a PBL methodology is an interesting vehicle for one of the essential purposes of the sound module, which is to introduce music students to the world of game sound.

H#4: A good part of the music students, after this experience, would be interested in continuing to develop projects in this area (game sound).

H#5: The presence of a more experienced student class monitor [2] in each team (as a kind of a manager) facilitate the development of the project.

H#6: This was the first experience of digital game students to produce a game with an external support team (sound team).

H#7: Working with an external team contributed to the learning process of game project development.

H#8: This experience prepares game students to work better with external teams in the future.

The first four hypotheses can be be evaluated based on questions to music production students. Hypothesis 5 can be analysed based on both classes. Hypotheses 6 to 8 can be evaluated based on questions to digital games students.

IV. Results

In this section we present the results obtained by this research based on questionnaires in forms for both classes.

A. Feedback from Music Production students

Table V presents 9 questions asked to the music production students, as well as the integrated results of their answers. In Questions 1 and 2 students only had the option of answering "yes" or "no". Based on the analysis of their replied, it can be seen that hypotheses H#1 and H#2 fully met our expectations, receiving agreement statements with percentages of 96% and 84% respectively.

For questions 3 to 9 we are interested in the consolidated result of the highest order items of the Likert scale. Regarding question 3, it is possible to aggregate the responses totaling 89.2% of agreement that "*Developing a real game project contributed to my introductory learning about sound production for games*". Question 4 brought an additional reflection for not having such a concentrated general answer. 64.3% of the students stated that they are interested in developing new game sound projects, which is below what we imagined. In our view, this may be due to the fact that many audio production students may be more interested in other aspects of the course (music production for advertising, cinema, etc.). In our view this topic requires further investigation in the future.

[2]The class monitor (or student monitor or just monitor), in our context, is a student with more experience (veteran) in a specific subject and who is allocated in classes to help others.

Question 5, in the same way as the previous one, brought the information a little spaced, integrating a total of 67.8% of positive statements. As it was an issue that allowed for comments, it was possible to observe that a good part of the students, despite agreeing that the presence of the class monitor brought an extra resource to the development of the project, reported that they ended up making little use of this resource. This explains the 28.6% centered on *Neither agree or disagree*.

It is interesting to note that questions 6 and 7 had high student agreement, considering the sum of the higher grades: *Agree* and *Strongly agree*. This informs us that, according to music production students, both meetings (for 92.9%) and communication (for 89.3%) with the game team had a satisfactory result with regard to the progress of the project. Based on the answers to question 8, we observed that the vast majority of students (more than 71.4%) found that their previous experience contributed to the development of the project. It is worth noticing that the others (28.6%) needed more resources to develop and still successfully completed the project, based on the general evaluation of the projects by the teacher. For 85.7% in question 9, (the sum of *Agree* and *Strongly agree*), the teacher's support was important for the development of the project.

B. Feedback from Digital games students

Following the same reasoning as the form intended for Music Production students, in the case of Digital Games students we provided a series of questions detailed in Table VI. It is important to note that question 1 was the only exception to the rule of questions using a likert scale. Being a question with a "Yes" or "No" answer, it is natural to conclude that 86.2% have never worked with external teams responsible for developing a part of the work.

It is possible to observe that question 2 has 75.9% of affirmative answers, if we consider the sum between grades *Agree* or *Strongly agree*. This indicates that the vast majority of students concluded that they had learned more about the development of games, under the presence of an external sound team. Similarly if we observe the results of question 3, 65.5%. feel able to work with outsourced teams after the experience. It is important to note that the 27.6% of respondents in grade *Neither agree or disagree* indicate that a good part of the gaming students are in doubt about this topic.

Considering the analysis of the results .. Following the same logic presented in the analysis of the feedback from music production students, here we also added the percentages of answers in grades *Agree* and *Strongly agree* as a starting point to observe each question. Question 4 gave us 75.9% of positive affirmative answers, which indicates that the students clarified their doubts about the sound production, in meetings with the audio team. Despite the percentage of positive answers for question 5. being 69.0%, the fact that there is a wide distribution among the other grades draws our attention. Analyzing the students' comments, we observed that a part reported difficulties in communication and response time on the part

TABLE V: Summary of responses from Music Production students.

Question	No	Yes			
1) Before this module, had you already developed a complete game sound project (including sounds and music)?	4.0%	96.0%			
2) Have you already developed a sound and music project for other areas? (eg advertising, or cinema etc)?	16.0 %	84.0%			
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
3) Developing a real game project contributed to my introductory learning about sound production for games.	0.0%	3.6%	7.1%	7.1%	82.1%
4) I am interested in working with Sound for Games after the course.	14.3%	7.1%	14.3%	21.4%	42.9%
5) The support and monitoring of the class monitors were important for the good development of the integrated project.	3.6%	0.0%	28.6%	10.7%	57.1%
6) After meetings with the digital games students team, I understood the needs of the project.	0.0%	0.0%	7.1%	42.9%	50.0%
7) Communication with the digital games students team happened efficiently.	0.0%	0.0%	10.7%	25.0%	64.3%
8) My sound production background (the result of experience or previous modules) corresponded to the needs of the project.	0.0%	10.7%	17.9%	14.3%	57.1%
9) The support and monitoring of the teacher was important for the development of the integrated project.	0.0%	3.6%	10.7%	10.7%	75.0%

TABLE VI: Summary of responses from Digital Games students.

Question	No	Yes			
1) Before his module, have you ever worked on game projects with outside teams to ”outsource” some of the production?	13.8%	86.2%			
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
2) Develop a game with an external team dedicated to sound design contributed to my learning in game project development.	3.4 %	0.0%	20.7%	31.0%	44.8%
3) I am interested and feel more prepared to work with external outsourced teams on games projects after the module.	6.9%	0.0%	27.6%	20.7%	44.8%
4) After meetings with the sound team, I better understood the sound production needs for the project.	0.0%	3.4%	20.7%	27.6%	48.3%
5) Communication with the sound team happened efficiently.	6.9%	13.8%	10.3%	24.1%	44.9%
6) The sound and music production made by the sound team met the needs of the project.	0.0%	6.9%	17.2%	10.3%	65.6%
7) The support and monitoring of teachers were important in the good development of the integrated project.	0.0%	0.0%	13.8%	17.2%	69.0%
8) The support and monitoring of the class monitors were important in the good development of the integrated project.	3.4%	6.9%	17.2%	17.2%	55.2%

of the audio team. Question 6., with a positive percentage of 75.9%, confirms that the sound production met the needs, even if partially as indicated by the percentage of 17.2% indicated in *Neither agree or disagree*. The game students perceived the support of teachers as important (86.2%) and from the monitors 72.4% as indicated in questions 7 and 8 In the case of this last question, in the students' comments it was possible to observe that a good part (17.2% in grade *Neither agree or disagree*) considered the presence of monitors, but reported that there was no need to resort to them.

V. Discussion and Related work

Digital games have been widely used as a tool to the teaching and learning process [12]. Supported by extensive research, [13] and [14] cataloged hundreds of games developed with the aim of supporting and engaging the student in learning, with a particular focus on the study of topics in the area of computing and engineering. Clark et al. [15] pointed out the effectiveness of digital games as a means for the learning purposes, comparing groups of engineering students who did and others who did not use this resource. The motivational effect of using games as a medium is pointed out by [16], and perceptual, cognitive, and behavioral advancement was reported by [17] and [18].

Music is commonly seen as the end of the teaching process that uses software for this objective, given the numerous games created for teaching music [19]. However, this is not necessarily a rule. Sound as a medium is an object of study in the discipline of Sound Art [20]. [21], inspired by the objective of teaching fundamentals of computing and engineering to students from other areas, developed a course where participants customize circuits and modify electronic devices creating sounds, noises, experimental and electronic music. In a playful way and inspired by the interaction with sound and music, those involved consequently learned the planned fundamentals, which was the authors' initial objective.

The idea of bringing together digital game development and music has also been explored in the works of [22; 23; 24]. In [22; 23], high school students were taught how to program in order to develop digital games that interacted with psychical digital music instruments. In [24] storytelling combined with sound design was used to teach game development undergraduate students to create more immersive text-based games.

Our work is placed in a specific scope where students

of digital games aim to produce a game, and students of music production aim to learn sound design. Additionally, as a secondary objective, it is desirable that the two groups, based on a common project, get to know the peculiarities of each other's area, as a kind of inspiration so that they can work in an integrated way.

Wand and Olivieri [25] developed a multidisciplinary project involving computing and arts students, including major students from both areas. The authors reported that they selected 40 students from different levels covering the aforementioned areas. Their module was developed using a model where two professors from different departments (computer science and sound design) conducted the work in the classroom with the objective of teaching topics from both areas together [26]. As the authors themselves reported, "their course emphasized the understanding and application of sound design within the context of video games". The similarity with our proposal is initially given by the joining of groups of students from different areas under the common objective of sounding a game, exercising the possibility of collaborative work. Differently, our groups of students studied different subjects with different learning outcomes, carefully planned to take place in parallel under a common IPBL objective.

According to the methodology we presented, digital game students had the autonomy to choose their teams (including developers and artists) and to propose the games they wanted to develop. In a second moment, music production students in pre-formed teams participated in a draw to find which games would be allocated. In contrast, Wang and Olivieri [25] proposed a final project (in the third phase of their teaching proposal) where all students, divided into groups of 4 components, participated in the complete construction of a game (from conception, design and development to the sound design). The authors of [25] took care to include an experienced sound designer and programmer in each group and define specific tasks for everyone.

We make use of interdisciplinarity in a different way from Wang and Olivieri [25] because they connect different areas of knowledge (computing and sound design) under the concrete objective that their entire group of students, which covers both areas, understand the application of sound design to games. In our case, all students develop a project that allows them to learn about the process of creating a sound game, deepening digital games students in the area of game production, and initiating music production students to the area of sound design for games. Additionally, game students exercise the dynamics of developing their work using external teams and music production students exercise the dynamics of being game audio service providers. Analyzing what has been exposed in this section, it is correct to state that our proposal and that of Wang and Olivieri [25] differ both in form and in the final objective. The application of one or another methodology is conditioned to the scenario that is set, which consists of how the students will be grouped and will carry out their work and the learning result expected from the groups. In a scenario where the focus is to teach introductory game audio without the need for game development, one option would be to use the PUCPR Sound Game (PSG) presented in [27].

VI. Conclusions and Future Work

The innovative practice reported in this paper confirmed one of the fundamental premises that inspired us to develop an integrative project between different areas of different schools: students united by a common purpose (in this case - to develop a complete sounded game) successfully achieve the expected learning outcomes in the subjects involved. The proposed model was inspired by an active PBL methodology suited to the interdisciplinary context: game and music students developed, within their specialties, parts of a common project. Naturally, the essential instrument we had to measure the result produced was the evaluation of the teachers in the subjects. The students' approval of the part they were assigned to in the projects could already serve as an indicator that the experience was successful.

Additionally, feedback from all the students involved allowed us to reflect on some hypotheses: (H#1) This was the first game sound production developed by music students (96%); (H#2) The students had not previously developed a sound and music project (for any area) (84%); (H#3) An integrated project proposed based on a PBL methodology is an interesting vehicle for one of the essential purposes of the sound module, which is to introduce students to the world of game sound (89.2%); (H#4) A good part of the students, after this experience, would be interested in continuing to develop projects in this area (game sound) (64.3%); (H#5) The presence of a more experienced student monitor in each team (as a kind of a manager) facilitate the development of the project (67.8%).

For each of the previous statements, we added the percentage of positive responses at the end. These results positively confirm hypotheses H#1, H#2 and H#3. The results regarding H#4 raises a reflection about the reasons that lead a part of music production students not to be interested in developing game sound projects in the future (35.7%). Some students reported their interest in focusing on other aspects of music production such as advertising and the movies industry. In the case of H#5, part of the students reported that they did not need help from monitors for the projects, which explains the 32.2% complement.

The following hypotheses were raised to game students: H#6: This was the first experience of digital game students to produce a game with an external support team (sound team) (86.2%); H#7: Working with an external team contributed to the learning process of game development (75.9%); H#8: This experience prepared game students to work better with external teams in the future (65.5%).

Based on the analysis of the results the majority of students confirmed H#6 and H#7. It should be noted that for H#8 there were 34.5% that did not positively confirm being able to work with external teams. Feedback from some students who want to do the exercise of working with external teams more often gives us some light in the sense that perhaps the process of

being able to do so requires repeating this exercise more often. These conclusions allow us to improve this process for new editions of the integrator project.

This research sought to use the already established thinking of active learning pedagogical methodology and PBL and its forms of action, experience and reflection in a interdisciplinary scenario. For educational purposes, we can say that the experience with the students and the exchanges were very rich, opening up new possibilities of scenarios for future research.

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